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UNITED STATES
COAST AND GEODETIC SURVEY

CARLILE P. PATTERSON
SUPERINTENDENT

METHODS AND RESULTS

AN ENQUIRY INTO THE
VARIATION OF THE COMPASS
OFF THE BAHAMA ISLANDS AT THE TIME OF THE
LANDFALL OF COLUMBUS
IN 1492

APPENDIX No. 19—REPORT FOR 1880

WASHINGTON
GOVERNMENT PRINTING OFFICE
1882

UNITED STATES

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AN INQUIRY INTO THE VARIATION OF THE COMPASS OFF THE BAHAMA ISLANDS, AT THE TIME OF THE LANDFALL OF COLUMBUS IN 1492.

By CHARLES A. SCHOTT, Assistant.

APRIL 12, 1881.

DEAR SIR: In compliance with your directions and at the request of the Hon. G. V. Fox, I have examined into the subject of the probable amount of the magnetic declination (commonly called "variation of compass") off the eastern coast of the Bahama Islands, at the time of Columbus' approach in 1492. The investigation is based upon such extracts from Columbus' journal as were furnished me by Mr. Fox and includes whatever other information I could obtain bearing upon the subject. In a brief interview I had with Mr. Fox (March 31), I took occasion to express my conviction of the impossibility of arriving at any very definite conclusion, partly on account of the extremely scanty material as to facts and partly in consequence of the want of assistance derivable from purely theoretical grounds; the cause of the phenomenon of the secular change of the magnetic declination being quite unknown and the time comparatively short during which to trace the law of change as hitherto observed. It will therefore not be surprising to find my conclusion given in the form of a reasonable conjecture rather than as a definite result. The present state of our knowledge of terrestrial magnetism does not appear to admit of a definite answer; besides, there are difficulties in the admission of certain evidence given by Fernando Colon.

Before entering upon the subject proper I beg to submit a few remarks in reply to a question bearing upon the early use of the compass and upon navigation towards the close of the fifteenth century. Respecting the ancient use of the magnetic needle or compass, on land and at sea, among the Chinese, with whom the practice originated, accounts will be found in Humboldt's Cosmos, vol. ii (Translation by Otté, London, 1849), and in the Encyclopædia Britannica (9th edition) vol. vi, 1877, art. Compass; there is also an extended account in the Encyclopædia of Experimental Philosophy, London, 1848 (part of the Encycl. Metrop'a.). B. F. De Costa, in a paper read before the Amer. Geographical Society (May, 1880), appears to have made certain extracts from the above works, viz., p. 9: "Necker (probably the same as Alexander Neckam—Sch.) abbot of Cirencester, who died in 1217, was acquainted with the use of the compass. Are Frode, in 1068, speaking of the visit paid to Iceland by Flocke Vilgerderson, says in those times seamen had no loadstone in the northern countries. In the fourteenth century Barber (Barbour) says of the party accompanying King Robert of Scotland from Arran to Carrick, 'they na nedil had na stane,' showing that these aids to navigation were then familiar to seafaring men." The curious story about one Peter Adsiger, of 1269, is satisfactorily disposed of in Walker's Terrestrial and Cosmical Magnetism, Cambridge (England), 1866. He shows that no such person lived.

The works quoted above also contain historical accounts of the compass during the middle ages. Flavio Gioja, a Neapolitan, in 1302, mounted his needles on a pivot and divided his compass into octants; however, needles placed on a pivot and carried on board ship were already referred to in the twelfth century (Alex. Neckam). In the sixteenth century compasses were divided into degrees and provided with sights (remarks of the Portuguese pilot, Alexis da Motta, about 1575), and before 1525 Felipe Guillen, an ingenious apothecary of Seville, constructed the first variation compass (Cosmos, vol. ii).

Referring to the times of Columbus, his compasses were probably divided into points of 11¼° and half points (quarters could be estimated). The distances sailed over were most probably estimated by him, since, according to Humboldt, the Admiral did not employ the log-line; time he measured by means of half-hour sand-glasses, and for his determination of position of the ship he probably used the astrolabe, just improved by Martin Behaim (who lived at Lisbon, between 1480 and 1484) for sea use and in connection therewith Behaim's or other tables of the sun's declination when observing the altitude of the sun. Humboldt asserts that the Admiral certainly carried with him Toscanelli's chart, sent him in 1477.

The following information and remarks I received from Mr. Fox, under date of April 1, 1881:

"Personal Narrative of the first voyage of Columbus to America, translated by Samuel Kettell. Published by Thomas B. Wail & Son, Boston; G. C. Carvill, N. Y. and Carey & Lea, Phila., 1827.

"Pages 18, 19: 'September 13, 1492. At the first of the evening of this day the needles varied to the N. W., and the next morning about as much in the same direction.

"'September 17: The pilots took the sun's amplitude and found that the needles varied to the N. W. a whole point of the compass, the seamen were terrified and dismayed without saying why. The Admiral discovered the cause and ordered them to take the amplitude again the next morning, when they found that the needles were true; the cause was that the star moved from its place while the needles remained stationary.'

"It seems incomprehensible that the observations of the next morning showed no declination, unless Columbus tampered with the card as he did in 1459-'63. (See Irving's Columbus, revised edition, 1854, vol. 1, p. 30.)

"On the 13th of September he was 224 leagues (672 geographical miles) west of Gomera, one of the Canaries, which Bowditch places in latitude 28° 06′ north, longitude 17° 08′ west. On the 17th he had gone 360 leagues west of Gomera, or 1 080 geographical miles. Thence he went to the Bahamas, northeast coast of Cuba, north shore of San Domingo (Haiti) and home without again mentioning the declination of the compass.

"Though he made three more voyages to the West Indies, the second from 1493 to 1496, third from 1498 to 1500 and last from 1502 to 1504, he writes of the declination of the compass on the third voyage only, as follows—Select letters of Columbus, 2d edition, translated and edited by R. H. Major, London, 1870; printed for the Hakluyt Society, p. 131—'I remarked that from north to south in traversing these hundred leagues (300 geographical miles) from the said islands (Azores) the needle of the compass which hitherto had turned towards the N. E. turned a full quarter of the wind to the N.W. and this took place from the time when we reached that line.'

"Page 135: 'For in sailing thence (Azores) westward the ship went on rising smoothly towards the sky and then the weather was felt to be milder, on account of which mildness the needle shifted one point of the compass; the further we went the more the needle moved to the N. W., this elevation producing the variation of the circle which the north star describes with its satellites.'

"In the Landfall of Columbus, by A. B. Becher, captain R. N., London, 1856, Appendix, pp. 330-337, are extended remarks about the declination. Captain Becher claims 2 points westerly declination in 1492 for the Bahama Islands. Columbus' remarks on the declination in his third voyage do not refer to the coast of Paria but to the route west of the line of 100 leagues west of the Azores."

Under date of April 2, Mr. Fox writes: "I have found Captain Becher's authority for saying that Columbus discovered 1½ points westerly variation on the 16th of August, 1498. In Collection of Voyages and Travels, by Churchill, London, 1732, vol. ii, p. 587, is the following extract from Ferdinand Columbus' life of his father:

"'Yet the Admiral says he could not from this time give such an account of it as he would wish, because through overmuch watching his eyes were inflamed, and therefore he was forced to take most of his observations from the sailors and pilots. He also says that this same night, being Thursday, the 16th of August, 1498, the compasses which till now had not varied, did at this time at least a point and a half and some of them two points, wherein there could be no mistake because several persons had always watched to observe it. Admiring at this and grieved that he had not the opportunity of following the course of the continent, he held on N. W. till on Monday the 20th of Aug. he came to anchor between Beaca and Hispaniola.'

"This declination seems to have been determined, August 16, the day after he left the coast of Paria, at a place where the island of Margarita bore west. The east point of that island by

Bowditch is in latitude 10° 59′ north, longitude 64° 30′ west. Ferdinand has been accused of many misstatements and errors of date. His history has never been found. All translations are from an Italian copy. Columbus, as I have quoted to you from his third voyage, refers, in speaking of the declination, to what he discovered 100 leagues west of the Azores in his *first* voyage. I think, therefore, that Ferdinand wrote from memory, not having his father's letter before him, which we have. He was not a sailor. He says, until *now* the compasses had not varied. Columbus was about Paria from the 1st of August, and yet he says they did not vary until the 16th. As we have Columbus' own letters of this voyage wherein he speaks of the declination, I think we cannot say that there was 1½ points (W.) declination on the coast of Paria in 1498."

Returning to the Admiral's remarks in his first voyage, we may be certain of the fact that on September 13, 1492, he had reached far enough to the westward to come from a previously eastern declination within a region of westerly declination and that on September 17 it amounted to a whole point (11¼°). This constitutes his well-known discovery of a part of a line of no-declination.

Two hundred and twenty-four leagues, or near enough for our purpose, 672 nautical miles west of the island of Gomera would place him on September 13, in latitude 28° 06′ north and in longitude 12° 42′+17° 08′=29° 50′, according to Bowditch, or if we take the position of the harbor of Sebastian near the eastern point of Gomera Island, according to admiralty chart No. 1873, viz, latitude 28° 05′.5 and longitude 17° 06′.3 and considering that 11° 12′ correspond to 12° 42′ of difference of longitude in that latitude, we have for a point in the line of no-declination the latitude 28° 05′ and longitude 29° 48′. In E. Walker's treatise on Terrestrial and Cosmical Magnetism, Cambridge (England), 1866, p. 300, we read: "The history of this line dates from the 13th of September, 1492, when Columbus observed the needle pass from the east to the west of the meridian in latitude 28° N., longitude 28° W." (probably roughly adding 11° of difference of longitude to 17° for longitude of Gomera). According to my computation of the daily position of the Admiral's flagship and based upon his log-book, he was on September 13 in latitude 28° 21′, longitude 29° 16′. It is evident that the extract from the third voyage is but an amplification of his first account and expresses his conviction that west of the Azores, where the declination was a little easterly it changed to the westward, being nearly zero at Corvo and gradually increasing to one point or 11° W. at a distance of 300 nautical miles W. of the longitude of Corvo. The position of Rosario on the S. E. part of the island of Corvo is, according to the Carta Esferica de las Islas Azores, Madrid, 1855, in latitude 39° 41′ and longitude 24° 53′ west of San Fernando, or in 31° 07′ west of Greenwich (according to the Conn. des Temps), 100 leagues or 300 nautical miles west of this longitude would correspond (in latitude 28°) to 5° 40′ and would bring the Columbus line in longitude 36° 47′ W. According to my computation of the daily track, Columbus was on September 17, 1492, in latitude 27° 38′ and in longitude 36° 30′, when he noted 11° west declination. The statement of Humboldt, in Cosmos, vol. ii (Otté edition) p. 657, is that 2½° *east* of Corvo the variation changed from E. to W. on September 13, 1492, he thus appears to take the longitude of Corvo as 31° and that of Columbus' position as 28½°. Though the accounts transmitted may admit of different interpretations there can be no question as to the fact of the discovery of a part of the line of no-declination passing towards the close of *the fifteenth century* from the vicinity of the Azores southward. At that time there was east declination at Palos, Spain, also at the Canaries and the eastern Azores. There was at that time but a slight westerly (not more than about 1½°) declination at Paris, France, as may be seen from my discussion of the observations made at Paris between 1541 and 1869 (see "Secular change of the magnetic declination," Appendix No. 9, Coast and Geodetic Survey Report of 1879, which is illustrated by a diagram herewith reproduced). Thus, the agonic line of 1492 must have passed a short distance to the south of Paris, France. In the Cosmos, as quoted above, Humboldt remarks: "The great Spanish navigator has not only the merit of having discovered a region in the Atlantic Ocean where, at that period, the magnetic meridian coincided with the geographical, but also that of having made the ingenious observation that magnetic variation might likewise serve to determine the ship's place with respect to longitude. In the journal of the second voyage, April, 1496 (on his home voyage), we find him trying to determine his position by the observed declination." Such an idea might well be entertained in an age when but the rudest means were available to the navigator for finding his longitude and when the course of the isogonic lines was but little understood; this idea is well known to have been revived in later times.

The course of the agonic line of 1492 towards the southwest is very uncertain, as it must entirely rest on the value we assume for Paria; and whether we accept the above circumstantial account given by Fernando in connection with Columbus' third voyage, or whether we reject it as vague and unreliable, our conclusion as to the declination in the West India Islands must in a great measure depend on it. Mr. Fox disposes of the matter in a very summary manner and while I reach the same conclusion, viz, that in all probability there was no west declination in that part of South America in 1492, I reach it on different grounds. If we accept the Paria observations it would necessitate a declination of not less than 2 points west for the Bahama Islands. Referring to the accompanying chart of the North Atlantic, showing the more or less probable positions of the agonic line for different early centuries, that for 1500 (answering equally well for 1492) has been laid down from the evidence cited in this paper, but its southwesterly course would either pass into the region between the Orinoco and Amazon Rivers, if Fernando's account was trustworthy, otherwise it would pass towards the Greater Antilles, as I conjecture it did.

Looking over the records and deductions for the secular change of the declination in the West Indies, in the fourth edition of my paper—Appendix No. 9, Coast and Geodetic Survey Report of 1879—we find there the earliest records for Havana, Cuba, 6° E. in 1700 and 4½° E. in 1730 and at Kingston, Jamaica, 6½ E. in 1660 and the same in 1700. The agonic line for 1600, as originally given, I have taken from Hansteen's Erdmagnetismus (1819). This line of 1600 mainly depends on Kircher's Ars Magnetica and on Purchas' Pilgrims, but in accordance with above facts I have shifted it towards the north, so as to traverse the northern part of the Caribbean Sea. It would seem to me that the line for 1500 requires a similar correction. Considering that the analytical expressions established by me in the secular change paper referred to, for all stations in this region have a limited range of change, not exceeding 5° from a supposed average position, it will be seen from the early observations cited above that the limit of variation may have approached nearly to zero and that, unless a total change in the law of the secular progression of the declination took place in those early times, the statement by Fernando Colon as to west declination off the island of Trinidad must be regarded as spurious. Yet, in a matter of such extreme difficulty in the present state of our knowledge of the changes in the distribution of the earth's magnetism and while admitting that no certain or definite conclusion can be reached, I may, nevertheless, state as my opinion that at the time of Columbus' first landfall on one of the Bahama Islands the declination was *very small* and probably less than ¼ point west.

Reverting again to the chart of the positions of the agonic line of the North Atlantic, Humboldt, in his Examen Critique, refers to Gilbert's Physiologia Nova to show that in 1600 the line of no-declination still passed through the Azores; and it may be noted that Sir Walter Raleigh's observation* on October 28, 1617, in latitude 7° N., longitude 28½° W., viz, 7°, and he thinks *east*, falls in well with the corrected curve on the chart. In the Azores, at Funchal Bay, the declination was observed 3° 05′ E. in 1589 and at Santa Maria 1° 40′ E. in 1610. At the Cape de Verde Islands the declination was observed 3° 30′ E. in 1610 (see Encyclopædia of Experimental Philosophy, London, 1848, p. 836). The line for 1700 is well founded and is taken from Halley's magnetic chart (Tabula Nautica, Variationum Magneticarum index, juxta observationes, anno 1700), reproduced in the Greenwich observations for 1869. Respecting the position of the lines for 1800 and 1880, no further remarks are required in this place. The motion of an agonic line may be regarded as typical for the motion of other isomagnetic lines in its vicinity and which may be taken as running parallel to it within certain limits. Between 1600 and 1880 the agonic line turned in the direction of the hands of a watch through fully a right angle, but between 1500 and 1600 the motion appears to have been partly retrograde. To obtain some idea as to a *scale of change* for distance from the earlier agonic lines, we may use the American observations made on our coast, on or near the Gulf of Maine, by Hudson and Champlain, between 1604 and 1612; their average result is nearly 18° W. We can do no better than suppose the scale also to apply to distances from the agonic line of 1500, corresponding to and, for intermediate values of west declination, proportional to the distance of our coast from the line of 1600; but at best this would be a very rough proceeding.

In response to a second inquiry, respecting the track of Columbus between Gomera and his first landfall, I would remark that the computed latitude of the landfall depends almost entirely on the assumed declination along his track (*de facto*, the problem might be inverted and from a known position of the landfall the distribution of the magnetic declination might be inferred). In strict adherence to the conclusion I came to respecting the magnetic declination, I have adopted the daily values as given in the accompanying table of resulting positions. The courses were corrected so as to represent true courses. The magnetic courses and distances in leagues are those given in Columbus' log-book; the latter were converted into nautical miles roughly by taking one league equal to three nautical miles, or three minutes of arc of a great circle of the earth's surface considered as a sphere.

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* Mr. Fox gives the reference "Hakluyt," vol. iii, p. 196.

According to Clarke's figure of the earth, a nautical mile is nearly 1 855.3 meters, or 6 080.3 feet. Fortunately the actual length of the Columbus league—that is, the league of his time, and, what is more important, *his practical conception of it*, that is, his and his pilots' *estimates* of its length—does not seriously affect the result of our problem, as will appear from the consideration that the total distance must land him somewhere on the eastern line bounding the Bahama Islands; and if we find his distances to overrun this limit, which I found to be the case, all we have to do is to diminish them by a suitable percentage. Accepting the length of the Columbus league as given by Mr. Fox, viz, 6 456 yards and computing the track across the Atlantic, I found it necessary, in accordance with the above indispensable condition, first to reduce the distances by one-tenth and then by one-hundredth more, which lands me just inside the line of keys. Columbus, when departing from Gomera, apparently took a northerly course in clearing it, so as to elude more easily the Portuguese, who were on the lookout for him at Hierro.*

Track of Columbus in 1492 *across the Atlantic, from the Canary Islands* (*Gomera*) *to the Bahama Islands.*

Date.	Distance in leagues.	Course, magnetic.	Corrected distance, nautical miles.	Declination allowed.	True course azimuth, from S. to W.	Latitude φ.		Longitude λ.	
				°	°	°	′	°	′
Sept. —	3	....	8.5	....	....	28	14	17	14
8	9	W.	25.5	3 E.	93	28	15	17	43
9	49	W.	138.9	2	92	28	20	20	21
10	60	W.	170.1	1	91	28	23	23	34
11	40	W.	113.4	0	90	28	23	25	43
12	33	W.	93.6	0	90	28	23	27	29
13	33	W.	93.6	1 W.	89	28	21	29	16
14	20	W.	56.7	3	87	28	18	30	20
15	27	W.	76.6	5	85	28	12	31	46
16	39	W.	110.6	7	83	27	58	33	51
17	50	W.	141.8	8	82	27	38	36	30
18	55	W.	155.9	8	82	27	16	39	24
19	25	W.	70.9	8	82	27	06	40	42
20	7.5	W. by N.	21.3	8	93.25	27	07	41	06
21	13	W.	36.8	8	82	27	02	41	47
22	30	W. N. W. N. W. N.	85.0	8	104.5 127 172	27	23	43	20
23	22	W.	62.4	8	82	27	53	44	06
24	14.5 4.5	W. W.	41.1 12.8	8	82 82	27	48	44	52
25	17 16	S. W. W.	48.2 45.4	8	37 82	27	08	45	39
26	15	S. W.	42.5	8	37	26	28	46	58
27	24	W.	68.0	8	82	26	18	48	13
28	14	W.	39.7	8	82	26	13	48	57
29	24	W.	68.0	8	82	26	03	50	12
30	14	W.	39.7	8	82	25	58	50	55

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* Port of Hierro (Spanish) or Ferro (Portuguese), on the northeast coast of the island, is, according to Admiralty Chart No. 1873, in latitude 27° 46′.2 and longitude 17° 54′.2

Track of Columbus in 1492 across the Atlantic, from the Canary to the Bahama Islands—Continued.

Date.		Distance in leagues.	Course, magnetic.	Corrected distance, nautical miles.	Declination allowed.	True course, azimuth from S. to W.	Latitude φ.		Longitude λ.	
					°	°	°	′	°	′
Oct.	1	25	W.	70.9	8	82	25	48	52	14
	2	39	W.	110.6	7	83	25	32	54	16
	3	47	W.	133.2	6	84	25	19	56	43
	4	63	W.	178.6	5	85	25	03	59	59
	5	57	W.	161.6	4	86	24	52	62	57
	6	40	W.	113.4	4	86	24	45	65	01
		23	W.	65.2		86				
	7	5	W. S. W.	14.2	3	64.5	24	34	66	27
	8	11.5	W. S. W.	32.6	3	64.5	24	20	66	59
		6	S. W.	17.0		42				
		5	W. by N.	14.2		98.25				
	9	20.5	W. S. W.	58.2	2	65.5	23	45	68	24
	10	59	W. S. W.	167.3	1	66.5	22	39	71	12
		27	W. S. W.	76.6		66.5				
	11	17	W.	48.2	0	90	22	09	73	19
		5.5	W.	15.6		90				
	12	2	W.	5.7	0	90	22	09	73	42

The total developed course is 3 150 nautical miles and it is surprising that simply by dead reckoning, over so long a track, a result should be reached which cannot be far from the truth. By adopting more *west* declination along certain parts of the track, say, 11° instead of 8°, the landfall would be materially *depressed* into a lower latitude, in fact, the result is latitude 21° 13′, longitude 71° 29′. which would place the landfall in the vicinity of the Turk Islands; in this case the developed track was 3 054 nautical miles. The more westerly declination we allow, the more *will* the track be deflected to the southward and this confirms the previous conclusion of the improbability of much westerly declination in the West Indies about the time of Columbus. Making little or no allowance for declination the track may be carried to the north and there are those who have placed the landfall as high north as Cat Island.

The above calculation terminates the track near Mariguana Island, but the uncertainty in the magnetic data is so great that it may be swayed all along the region between Grand Turk and Samana; to this uncertainty we must still add that arising from currents and it is not unlikely that between October 9 and 12 a northwest current was met with. It does not appear that we have any record of astronomical determination of latitudes, either on board ship or on land, made by the Admiral. There is another and apparently far more promising method of investigation for the position of his first landfall than that of following the Admiral across the Atlantic, viz: the inverse proceeding of starting from an identified landing-place on the eastern end of Cuba and tracing his courses and distances, as recorded, *backwards* to his first landfall. Here the variation of the compass may be taken zero. A third method may be based upon the physical aspects of the islands as described by him.

Yours, respectfully,

CHAS. A. SCHOTT,
Assistant United States Coast and Geodetic Survey.

Mr. CARLILE P. PATTERSON,
Superintendent United States Coast and Geodetic Survey.

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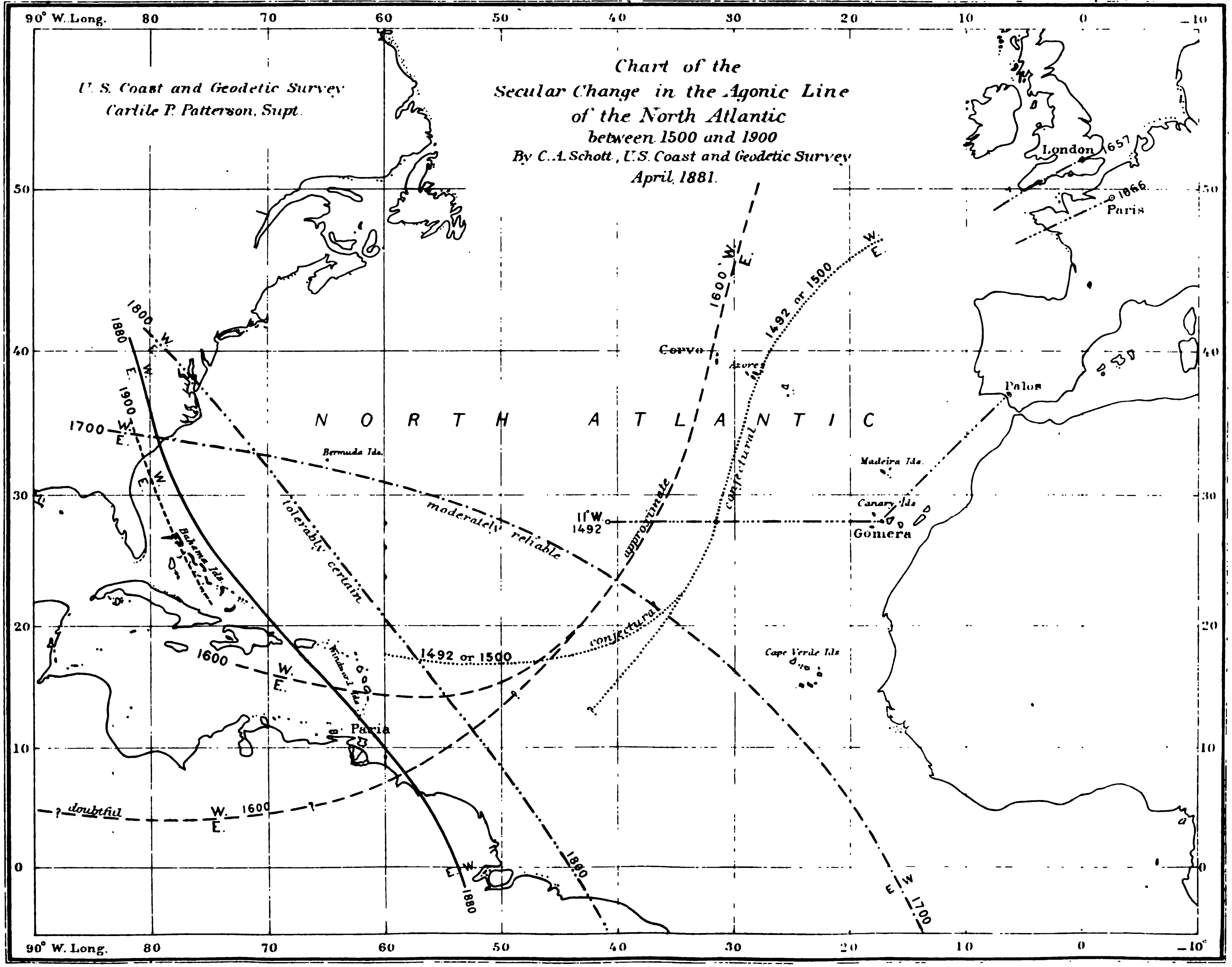

Chart of the Secular Change in the Agonic Line of the North Atlantic between 1500 and 1900

By C. A. Schott, U. S. Coast and Geodetic Survey

April, 1881.

U. S. Coast and Geodetic Survey

Carlile P. Patterson, Supt.